

Transitioning Ensemble-based TC Track and Intensity Sensitivity to Operations: Current Status and Future Plans

Ryan D. Torn

University at Albany, SUNY



UNIVERSITY
AT ALBANY

State University of New York



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Overview

- Resource limitations make it difficult to observe the atmosphere everywhere
- Sensitivity analysis provides an objective method of identifying potential high-impact observation locations for a given forecast metric
- Current operational TC track targeting methodology is 20+ years old
 - based on steering flow standard deviation, but does not necessarily guarantee that this will impact forecast TC position

Overview

- Other ensemble-based methodologies, such as the ensemble-based sensitivity method, may be better suited because you can directly link to TC-related metrics
- First tested for observation targeting in a semi-operational environment during NOAA SHOUT campaign (2015 and 2016)
- Demonstrated with NHC forecasters using ECMWF forecasts during 2017 and 2018

Ensemble Sensitivity

$$\frac{\partial J}{\partial x_{t-\delta t, j} e} \equiv \text{cov}(\mathbf{J}, \delta \mathbf{X}_{t-\delta t, j}) \mathbf{D}_j^{-1} = \frac{\text{cov}(\mathbf{J}, \mathbf{X}_j)}{\text{var}(\mathbf{X}_j)}$$

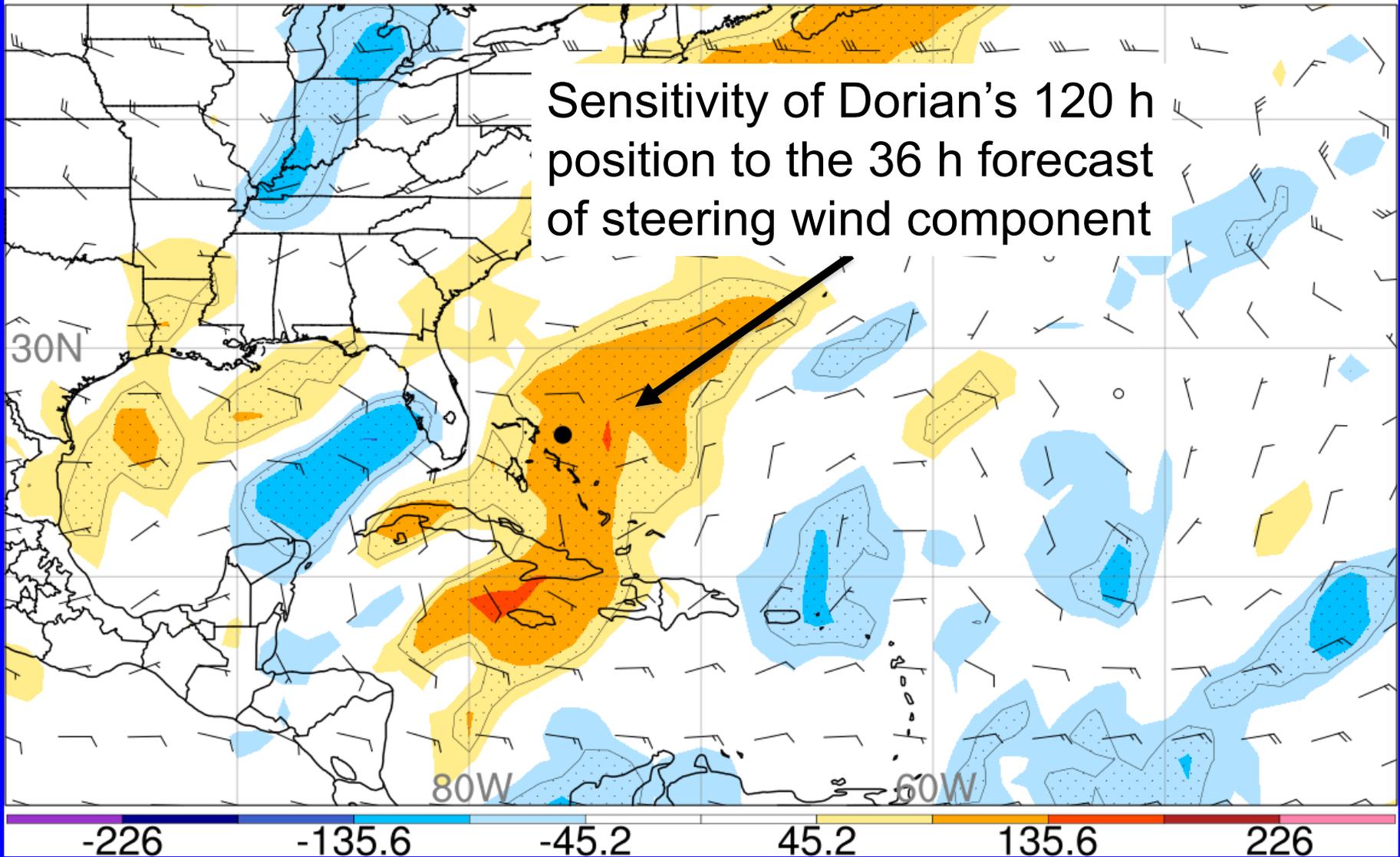
Ancell and Hakim 2007, Torn and Hakim 2008

- Ensemble-based method of computing the sensitivity to model state variables at earlier time
- Above equation is linear regression based on ensemble:
 - Dependent variable is ensemble estimate forecast metric (e.g., position along major axis of variability)
 - Independent variable is ensemble estimate of state variable at a location at an earlier time (e.g., component of steering flow)

Sensitivity Example

2019083100 F036

Sensitivity of Dorian's 120 h position to the 36 h forecast of steering wind component



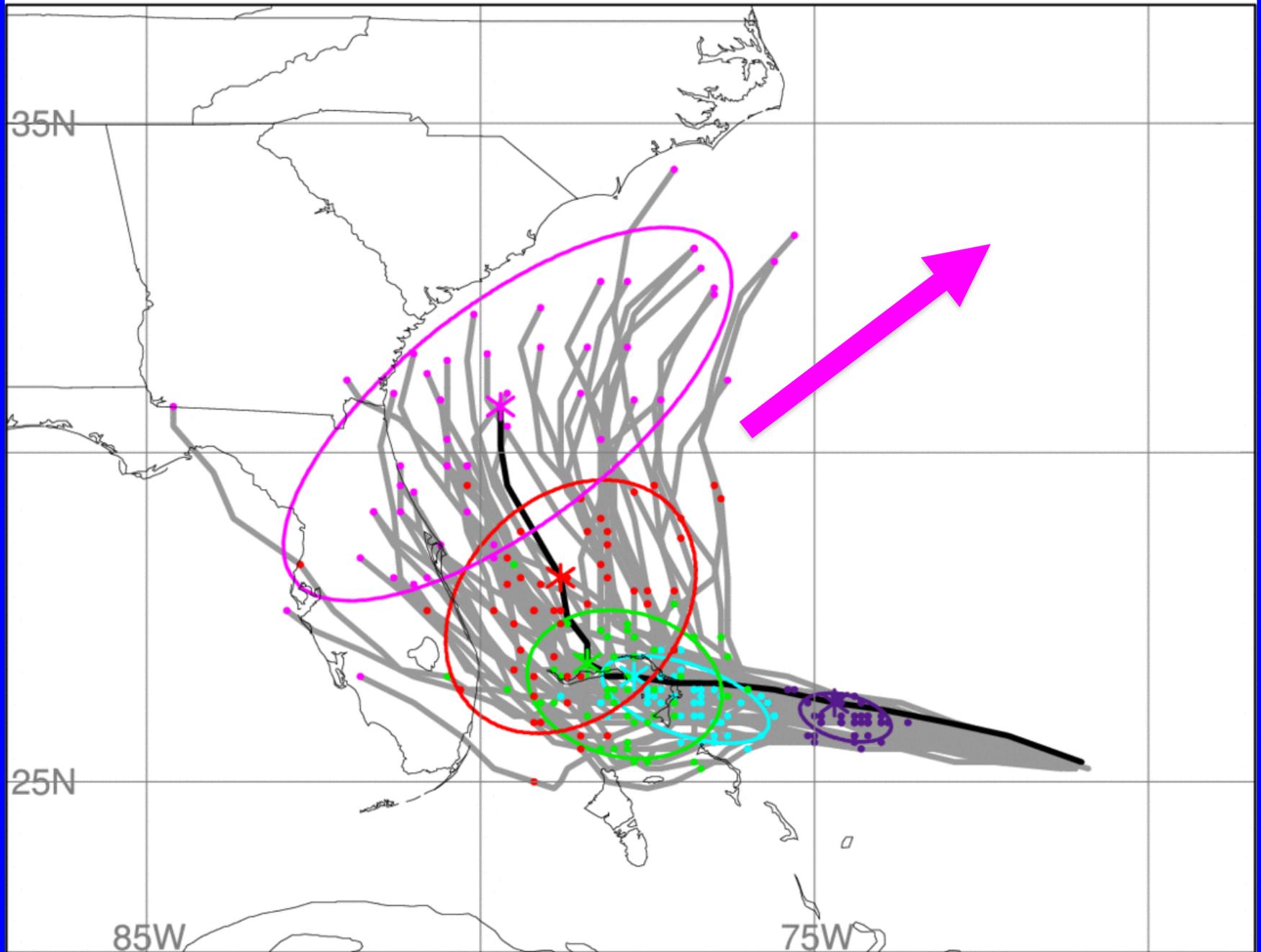
Project Objective

- Develop a concise ensemble-based sensitivity product that could be used to identify sensitive regions for TC track forecasts, which could be used to develop aircraft flight tracks and/or identify set of supplemental rawinsondes
 - Test new fields/metrics and figure styles that reduce forecaster analysis time
 - Write single, concise python package
 - Add capability to use sensitivity fields in traveling salesman software

2019 Highlights

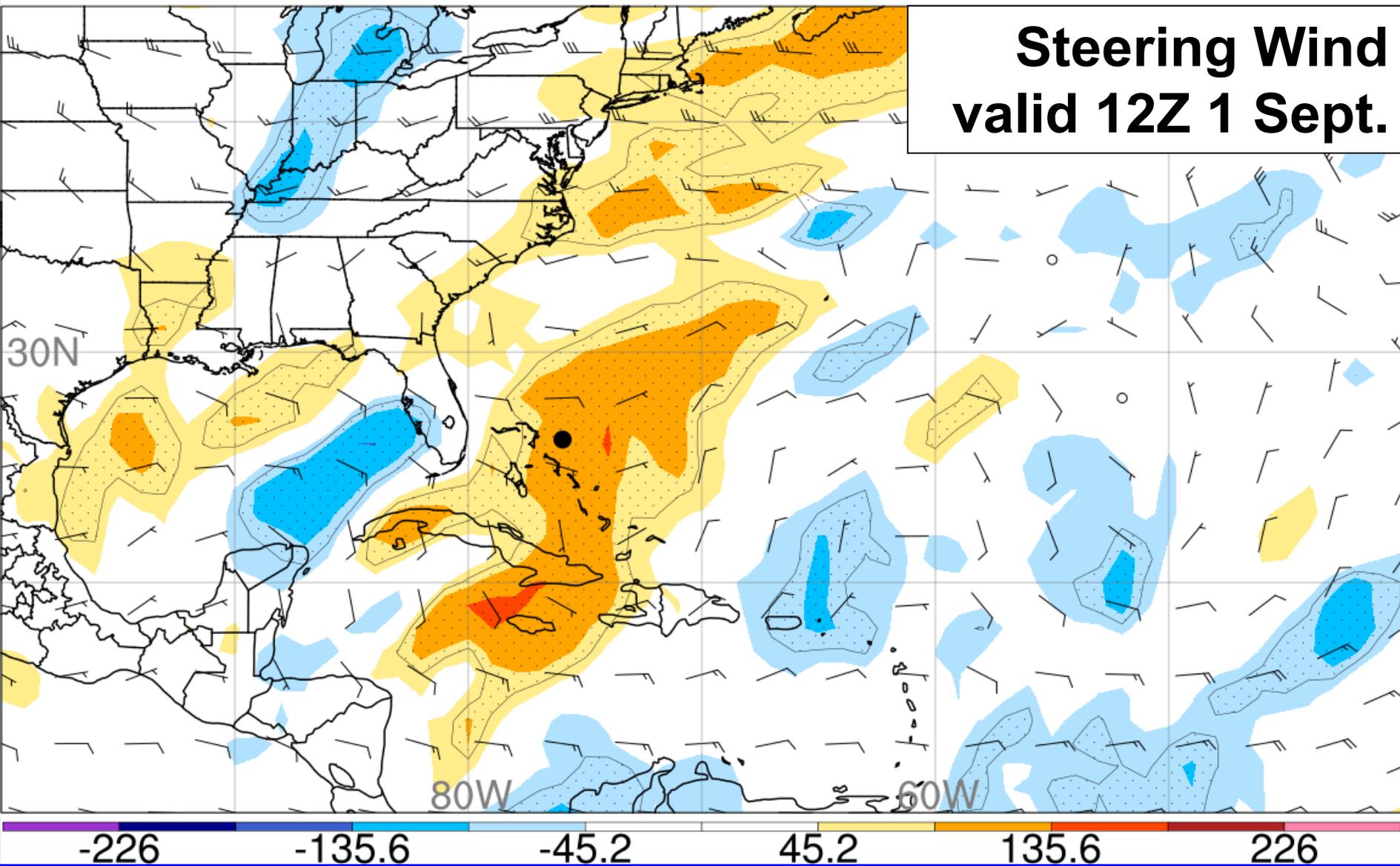
- Further demonstration of method in real-time using ECMWF ensemble forecasts in collaboration with NHC forecasters in charge of G-IV flight patterns
- Products generated within UAlbany computing environment
- Provided daily summary of sensitivity output on 17 potential G-IV flights for 3 storms
- Testing of new metrics and fields

2019083100 ECMWF forecast of dorian05l (al052019)

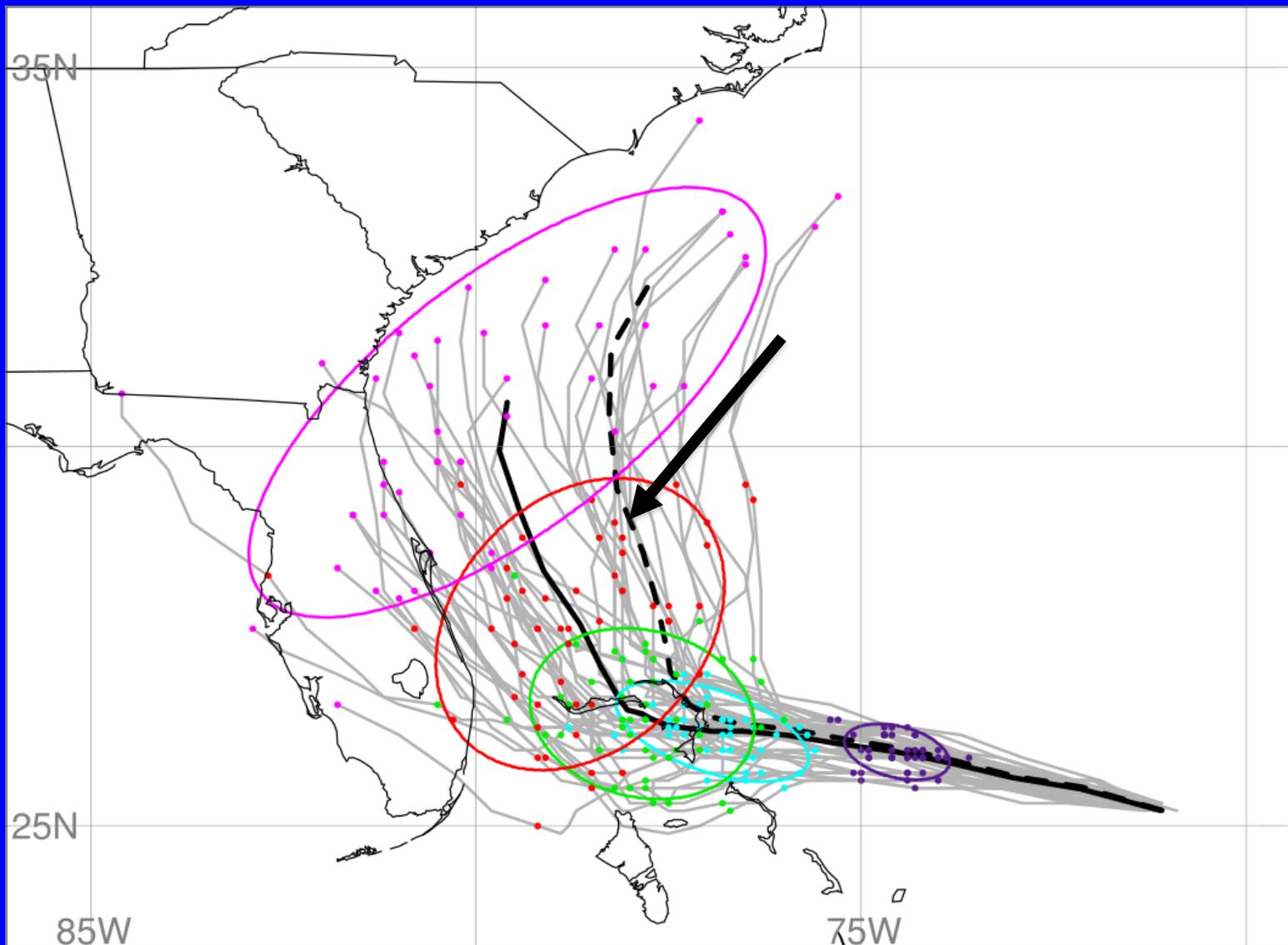


2019083100 F036

Steering Wind valid 12Z 1 Sept.



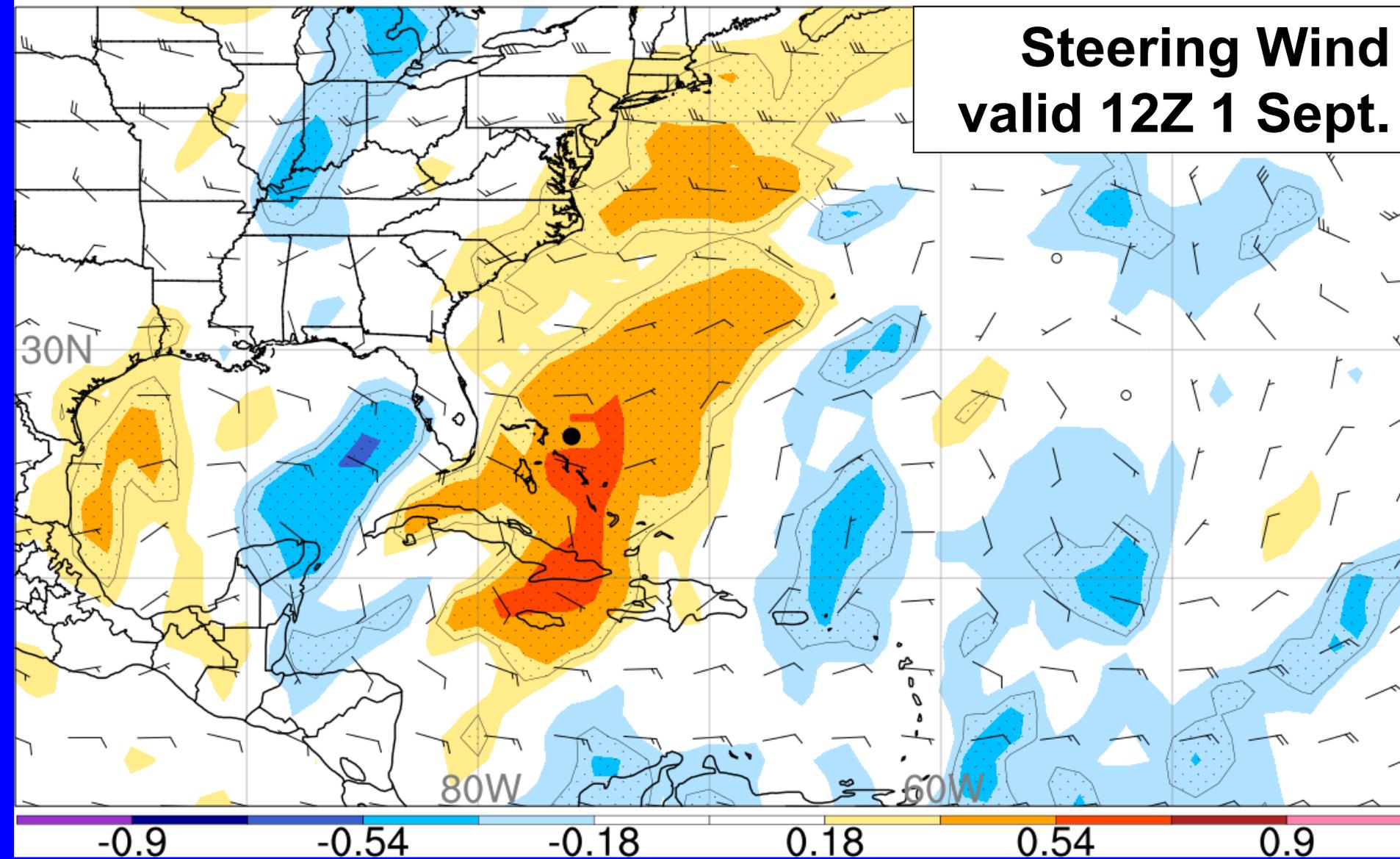
Hurricane Dorian, ECMWF forecast initialized 0000 UTC 31 August 2019



Compute EOF of entire ensemble TC position forecast. Metric is principal component of the first EOF (measure of how close ensemble is to particular forecast trajectory). Extension of current method to multiple times.

2019083100 F036

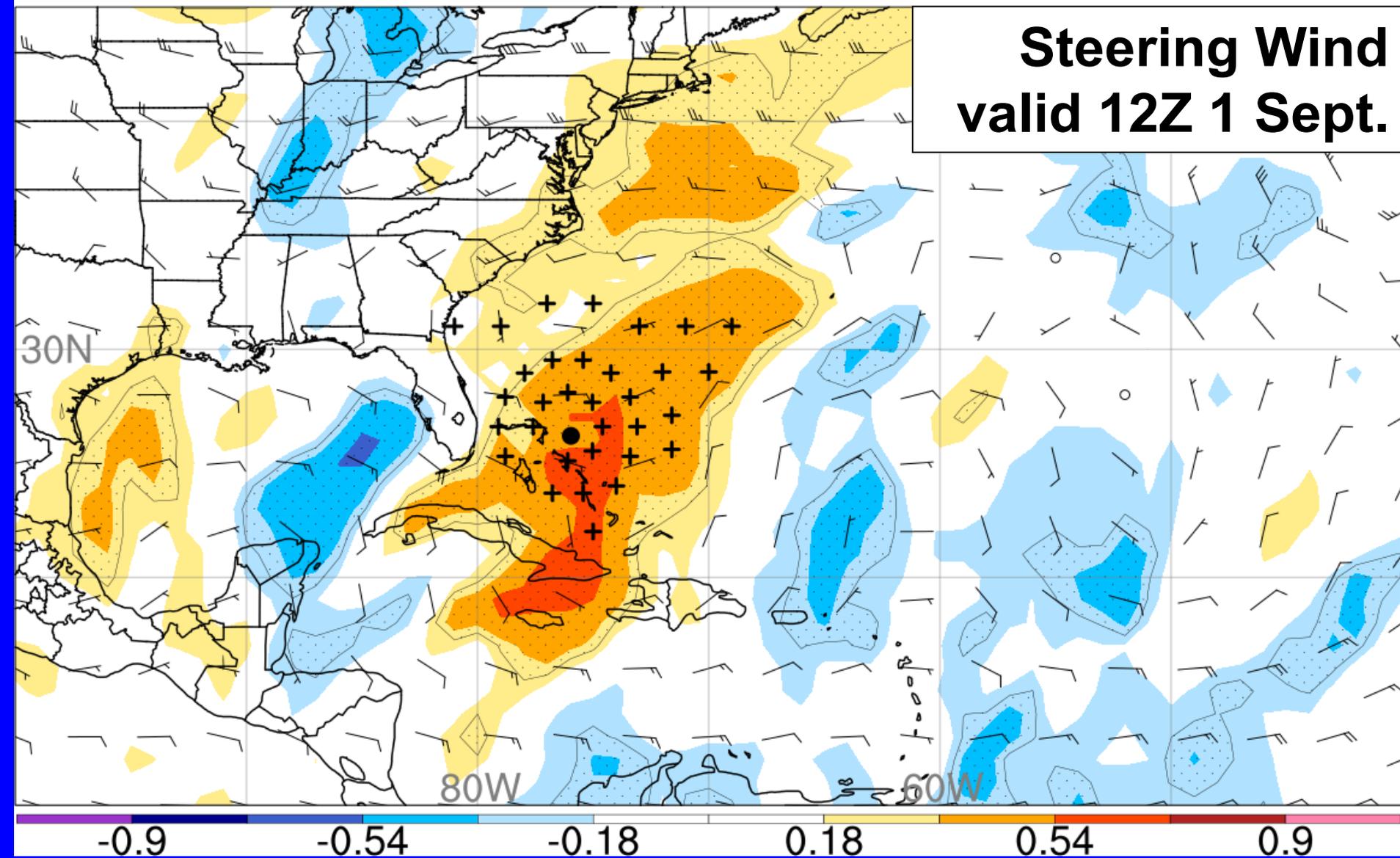
**Steering Wind
valid 12Z 1 Sept.**



Hurricane Dorian, ECMWF forecast initialized 0000 UTC 31 August 2019

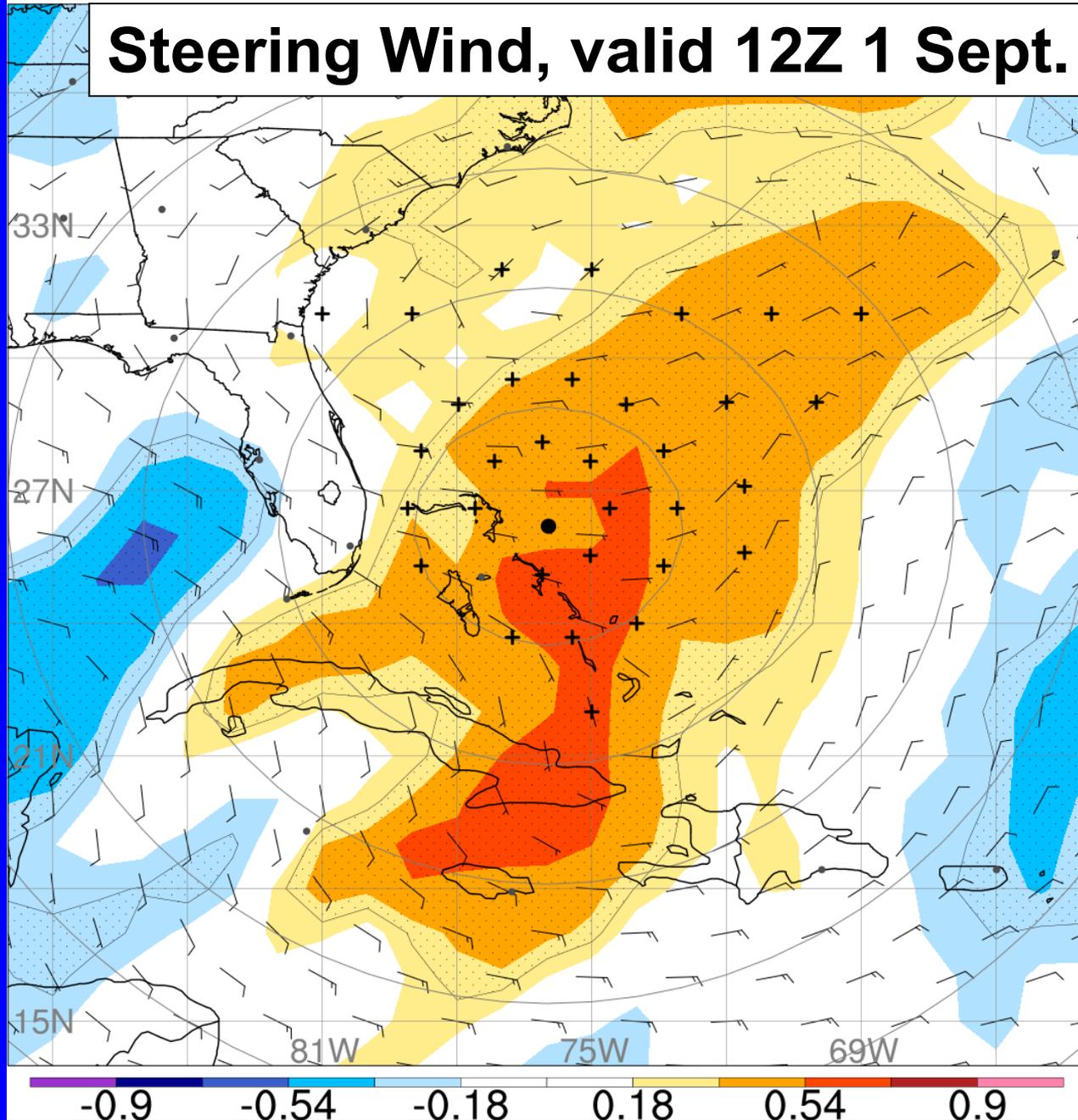
2019083100 F036

Steering Wind valid 12Z 1 Sept.

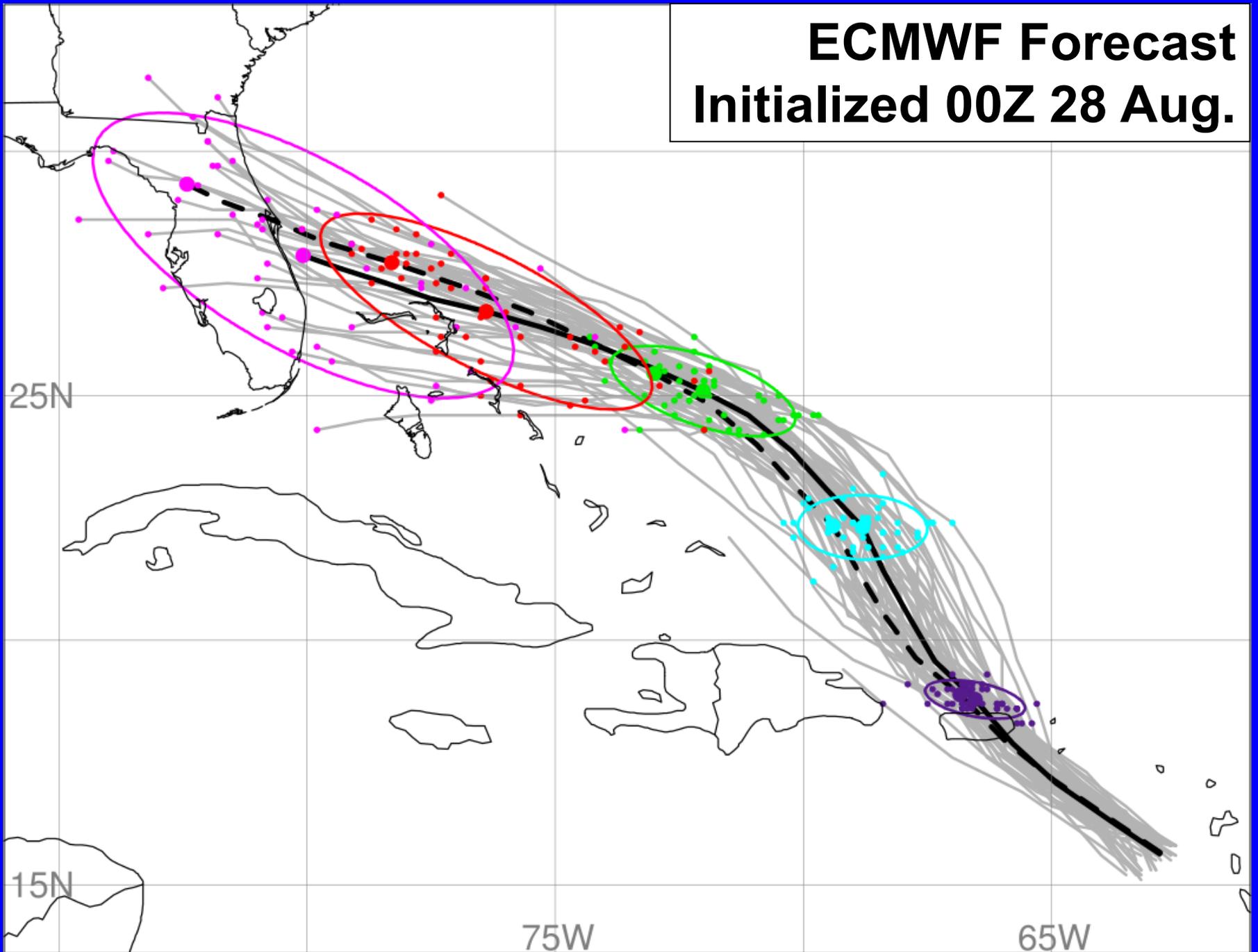


Hurricane Dorian, ECMWF forecast initialized 0000 UTC 31 August 2019

Steering Wind, valid 12Z 1 Sept.

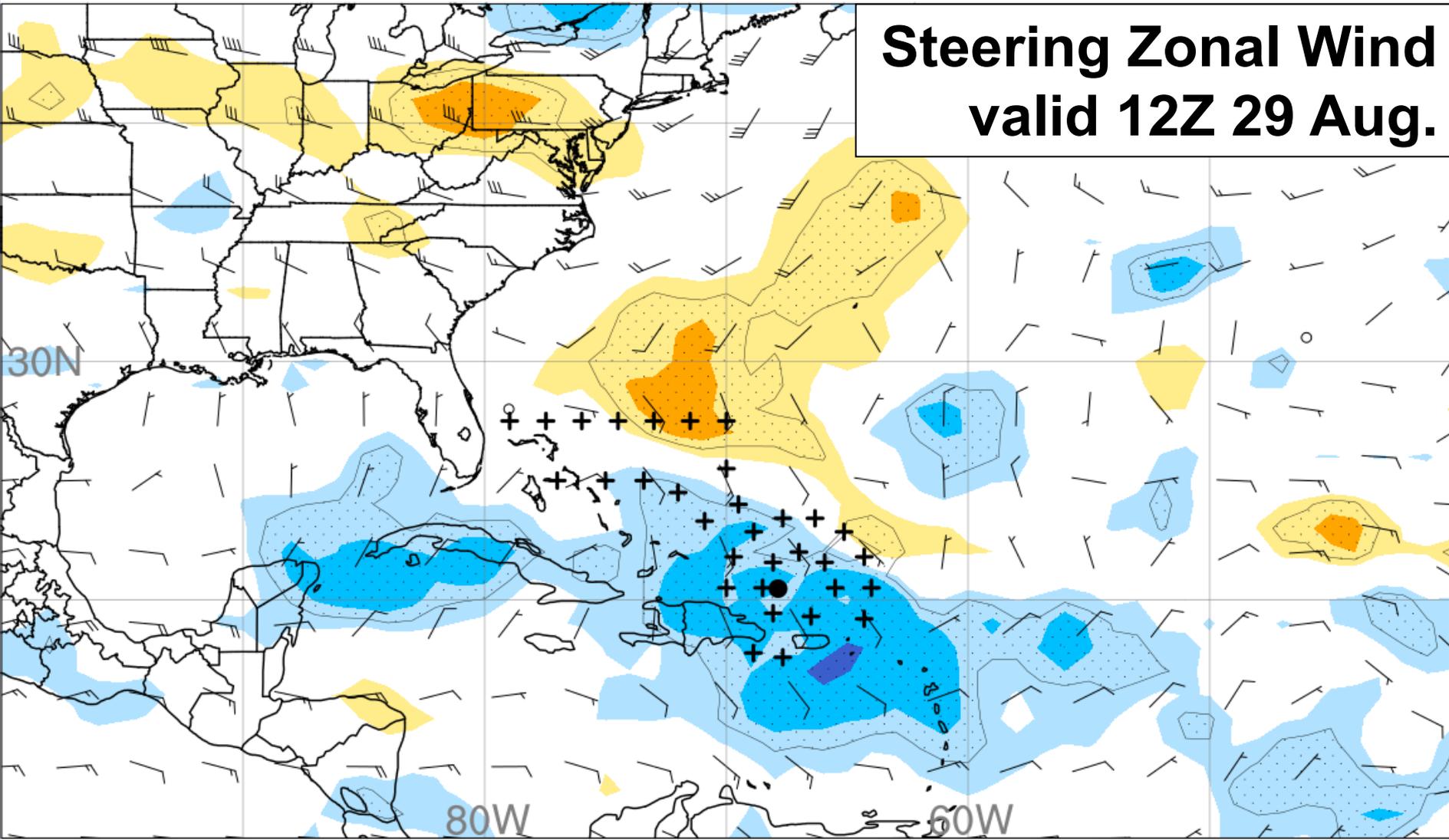


ECMWF Forecast Initialized 00Z 28 Aug.



F036 Layer-Average Zonal Wind

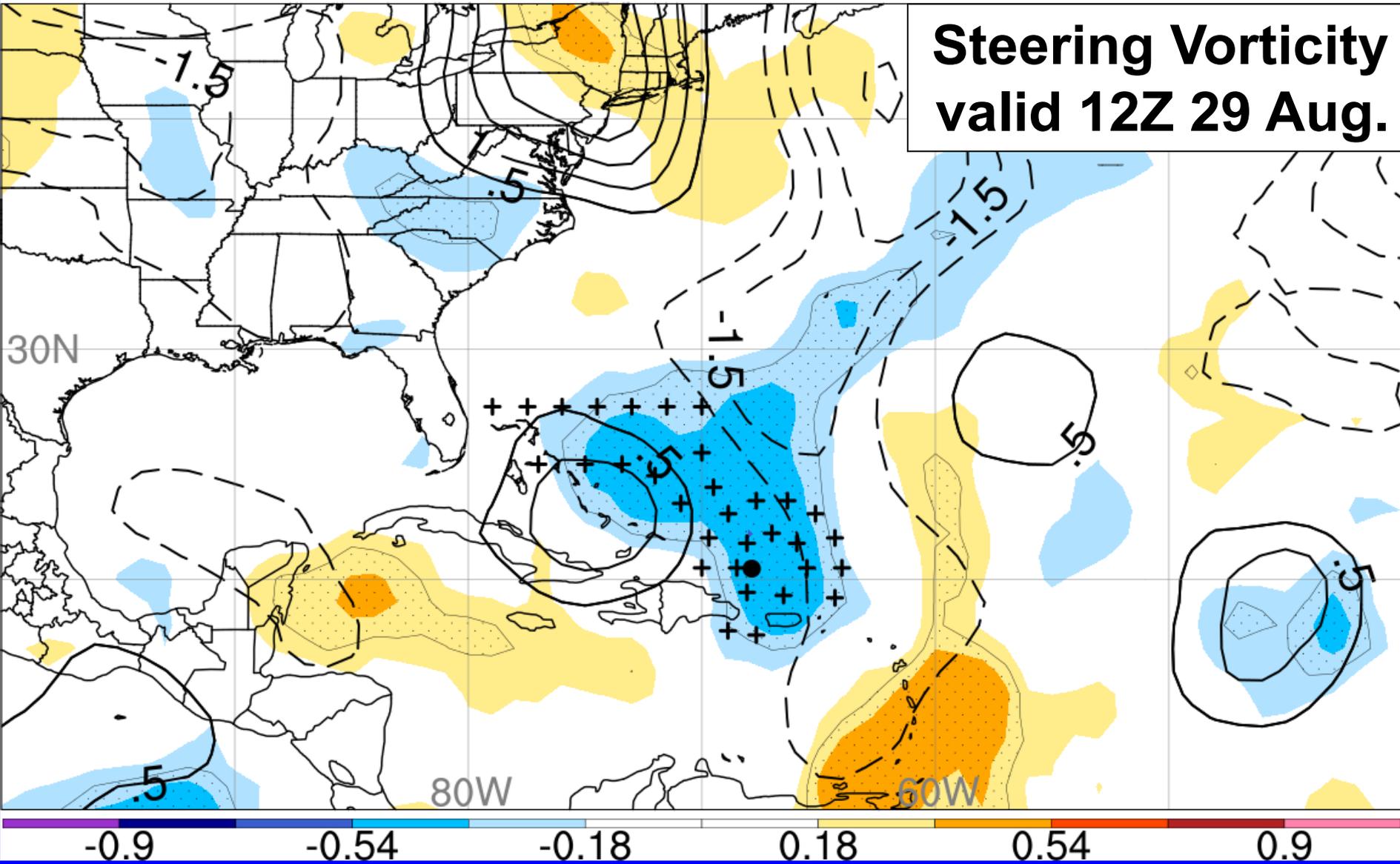
Steering Zonal Wind valid 12Z 29 Aug.



Hurricane Dorian, ECMWF forecast initialized 0000 UTC 28 August 2019

F036 Steering Circulation

**Steering Vorticity
valid 12Z 29 Aug.**



Hurricane Dorian, ECMWF forecast initialized 0000 UTC 28 August 2019

Future Plans

- Update 2019 procedure for 2020 season
- Run python-based software in parallel with software package run during past seasons
 - May include additional parallel system on NHC computing system
- Apply technique to all storms, regardless of whether there is potential for aircraft operations
- Develop training module on how to use sensitivity output